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Research

Social learning for building community resilience to cyclones: role of indigenous and local knowledge, power, and institutions in coastal Bangladesh

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ABSTRACT. Despite wide recognition of the role of social learning in building community resilience, few studies have thus far analyzed how the power–knowledge–institution matrix shapes social learning processes that in turn foster resilience outcomes. Drawing insights from the biopolitical lens of resilience, we take a critical stance on programmatic interventions for community resilience and social learning, arguing that local knowledge, beliefs, practices, and social memory (SM) are crucial elements in social learning processes for building community resilience to shocks and stresses. In addition, we explore how technologies shape social learning processes and build or strengthen community resilience. Our research, conducted in cyclone-prone coastal zones of Bangladesh, adopts a transformative interpretive framework (TIF) and a community-based participatory approach to empirical investigation. Findings of our research provide evidence that formal institutions frequently exclude indigenous and local knowledge (ILK) from social learning processes, and often subjugate communities to notions of resilience, as defined by nonlocals, that perceive people as subjects of institutional power and objects of scientific knowledge, rather than as active agents. We further found that local communities are able to obtain early warnings of cyclones through ILK of environmental phenomena, such as changing water temperature and animal behavior. Despite an abundance of ILK regarding past cyclones, the 2007 Cyclone Sidr was a surprising event to many and caused considerable loss of life and property. Much of this unpreparedness stemmed from an overall SM deficit—a key to translating knowledge into action. We recommend strengthening efforts to bridge scientific–technical knowledge and ILK to ensure effective social-learning-led resilience outcomes are achieved.

Key Words: *Bangladesh; community resilience; cyclone; disasters; indigenous knowledge; local knowledge; power; social learning; social memory*

INTRODUCTION

The enhancement of community resilience to emerging risks, such as climate-change-induced extreme weather events, is an issue that has received a great deal of attention in both academic and policy domains (Cutter et al. 2008, Haque et al. 2018). Recognizing that resilience is often socially and politically differentiated, for the purpose of the present study, we broadly defined "resilience" as the (inherent) ability of a community to withstand external shocks and disruptions (Folke el al. 2010, Berkes and Ross 2013, Faulkner et al. 2018). This fundamentally depends upon the community members' capacity and opportunity for learning from crises and combining different forms of knowledge in order to effectively prepare for and respond to future crises (i.e., social learning) (Adger et al. 2005, Folke et al. 2003, Berkes 2007, Pahl-Wostl 2009). With this basic relationship in mind, we investigated risk reduction and community resilience to nature-triggered extreme events (NTEE) and associated disasters through a social learning lens, and posit that indigenous and local knowledge (ILK) is vital to the social learning process and for enhancing resilience to NTEE.

Numerous recent studies have rightly elaborated the problematic nature of normative framings of resilience (Cote and Nightingale 2011, Christensen and Krogman 2012, Fabinyi et al. 2014, Brown 2016) and the fact that resilience has frequently been found to be socially (e.g., gender), politically (e.g., power), and culturally (e.g., local knowledge) differentiated (Pelling 2011, Grove 2014*a, b*, Brown 2016, Jordan 2018). As the normative usage of resilience may obscure its relationship with vulnerability, facilitating social learning and building resilience require an understanding of these dynamics (Cannon and Müller-Mahn 2010, Gaillard 2010, Carr 2019). In this regard, some critical social theorists appropriately assert that resilience is essentially progressive and political as it envisions people as active agents who have control over their own destiny, rather than as passive subjects and victims (Grove 2013*b*, 2014*b*, Evans and Reid 2014, Barrios 2016). Support for this human agency perspective has also been registered in some applied community resilience scholarship, e.g., focusing on identifying, building, and nurturing local strengths (Brown and Westaway 2011, Berkes and Ross 2013, Faulkner et al. 2018). In this paper, we posit that an inter- and transdisciplinary engagement with the work of these critical social theorists and applied, pragmatically oriented scholars helps to better understand the process of resilience on the ground.

As a mechanism for sharing and developing common understandings, social learning for building resilience often involves external deliberative processes (Pahl-Wostl 2006, Armitage et al. 2008), and several authors have raised concerns regarding who defines resilience—and for whom (MacKinnon and Derickson 2013, Cretney 2014). They assert that if external deliberation (e.g., by formal institutions) does not meaningfully include local voices, knowledge, and memory, these processes are likely to subjugate people to the power of institutions and scientific–technical forms of knowledge (Adger et al. 2001, Bulley 2013, Grove 2014*b*). Here, unpacking the relational matrix of power, knowledge, and the institutional context is essential for

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understanding the role of social learning in building community resilience, which is often ignored in the social learning discourse.

Understanding tensions and differentials in power and knowledge is central to comprehending and explaining the "everyday forms of resilience" that are discursively produced and reproduced through social learning processes (Pelling 2011, Boyd et al. 2014, Brown 2016). Recognizing the plurality of approaches to knowledge, our intent is to explore diverse meanings and possibilities for alternative forms of resilience (Grove 2013*a*, 2018, Pugh 2013, Bonilla 2020). In this study, by taking a critical stance on programmatic interventions for community resilience and social learning, we argue that local knowledge, beliefs, practices, and social memory (SM) are critical elements of social learning processes for building community resilience to NTEE, such as cyclones and associated storm surges. As well, we assert that it is important to examine how these elements are being applied in power relations and how technologies play out in such social learning processes.

In our investigation, we consider ILK as a point of convergence between social learning and community resilience scholarship, and further link these fields to that of disaster resilience. We document and analyze the effects of various dimensions of ILK in reducing risks and building resilience to NTEE, the interplay between ILK and SM in shaping resilience, and the role of community-based institutions in replenishing SM and in the social learning process. We then present a critical stance on social learning and resilience to interrogate the role of external formal institutions in this process. In so doing, we aim to demonstrate, with empirical evidence, how formal institutions exclude ILK, and thus how social learning activities that promote more inclusive ILK can improve outcomes and facilitate alternative practices of resilience.

CONCEPTUAL CONSIDERATIONS

Indigenous and Local Knowledge, Social Learning, and Community Resilience to Nature-Triggered Extreme Events

The capacity of actors to learn and to combine different forms of knowledge (i.e., adaptability) is a prerequisite for building resilience (Folke et al. 2003, 2010). Various forms of learning and its outcomes are conceptualized in resilience literature, such as incremental, episodic, transformative, and social learning (Holling 2004, Berkes 2007, Gunderson 2010, Pelling 2011). We posit that, from a resilience perspective, learning implies system-oriented learning, i.e., social learning (Berkes 2007, Pahl-Wostl 2009), which can be incremental (single- and double-loop) or transformative (triple-loop). We consider social learning a useful lens to interrogate the connection between ILK and community resilience and have adopted Reed et al.'s (2010: 6) view of social learning as "a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks."

Social learning has diverse meanings, applications, connotations, and acquisition processes, and often involves individual-, network-, and system-centric approaches (Rodela 2011, 2013). In the climate-induced disaster risk and resilience context, it can be considered a process (deliberative and/or spontaneous) wherein different stakeholders participate in a collective learning platform to share their experiences and opinions, learn from each other, and come to a common understanding of the issues that contribute to adaptive resilience (Cutter et al. 2008, Johannessen and Hahn 2013, Baird et al. 2014). Social interactions and networks are thus central to the social learning process. However, it is also essential to critically examine such a normative conceptualization of social learning by investigating how power–knowledge plays out within institutional contexts that in turn shape social learning processes and resilience outcomes (cf. Armitage et al. 2008, Reed et al. 2010, Boyd et al. 2014, Ensor and Harvey 2015).

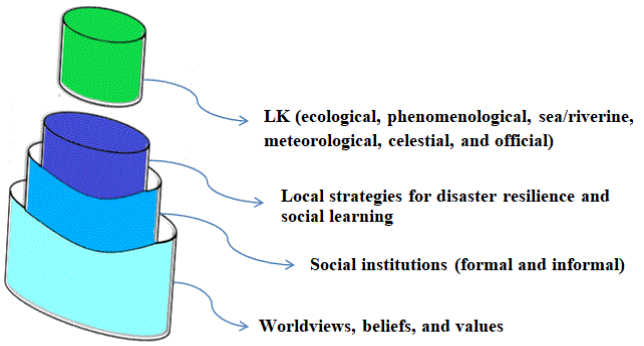
Despite a wide array of literature underscoring the importance and utility of ILK for building community resilience to shocks and stresses (Thomalla and Larsen 2010, Gómez-Baggethun et al. 2012, 2013, Kelman et al. 2012), the incorporation of local voice in the social learning process that is embedded in the idea of ILK has thus far been poorly studied (Briggs and Sharp 2004). Social learning must build on local strengths (e.g., ILK and SM) as these represent vital inner capacities or capital of a community (Magis 2010). Hooli (2016) extends this notion by asserting that achieving resilience among the poorest requires the incorporation of their knowledge and learning. Studies of social learning processes that focus on the implications of the inclusion and/or exclusion of local knowledge for building community resilience are nonetheless scant in the literature.

It is difficult to operationalize social learning in the case of episodic events like NTEEs. In natural disaster research literature, learning and knowledge are often used interchangeably (Pfister 2009), but social learning can be both a "process" through which knowledge is acquired and produced or an "outcome" in and of itself (Pahl-Wostl 2006, Armitage et al. 2008, Pfister 2009). For the purposes of this study, we consider ILK (including SM of disasters) as a surrogate of social learning. Indigenous and local knowledge is fundamentally social in character as it is situated within wider social entities or communities of practice. It is gained through a process of continuous accumulation from empirical observation and trial and error, transmitted from one generation to the next, and embedded within local institutions and practices (Dekens 2007, Berkes 2018, Trogrlić et al. 2019).

Indigenous and local knowledge reflects communities' inner strengths, which have the potential to improve preparedness as well as to reduce risk and enhance community resilience to NTEE (Berkes 2007, Kelman et al. 2012). It is a source of community resilience and adaptive capacity (Boillat and Berkes 2013, Gómez-Baggethun et al. 2013). Supporting and enhancing local strengths is also a key to community-based risk reduction (Thomalla and Larsen 2010, Choudhury et al. 2019). However, ILK is often narrowly defined in disaster risk reduction (DRR) and resilience literature, where the focus is primarily on acquired knowledge, ignoring social institutions, power relations, beliefs, practices, memory, and worldviews. In this respect, it is useful to draw insights from Berkes' (2018) framework for traditional ecological knowledge, which defines a "knowledge–practice–belief complex" consisting of "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmissions, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 2018: 8).

Analogous to Berkes' (2018) four interrelated levels of analysis, we offer a framework to investigate the function of ILK in DRR and resilience (Fig. 1). Indigenous and local knowledge is the first level of analysis and is at the core of this framework. Whereas Berkes (2018) developed his framework in the context of natural resources management and was largely concerned with the ecological aspects of ILK (e.g., species identification and behavior), our work focuses on disaster risk and community resilience. We expand this level by drawing insights from Acharya and Prakash's (2019) six dimensions of ILK (including ecological) that are relevant to DRR and resilience: (i) ecological (nonhuman behavior); (ii) phenomenological (anticipation of a probable disaster based on memory); (iii) sea/riverine; (iv) meteorological; (v) celestial; and (vi) official (information received from external institutions and electronic and print media). These dimensions of ILK often interact to provide early warning before the onset of disasters, which is likely to facilitate actions to prepare, reduce risks, and enhance resilience (Trogrlić et al. 2019). The phenomenological dimension includes SM, which has special significance for DRR and resilience (see section on SM below). The official dimension indicates that people often proactively integrate their own knowledge and experience with external knowledge and modern technologies (Hilhorst et al. 2015).

Fig. 1. Nested levels of analysis in ILK for DRR and resilience [after Berkes 2018].



In the second level of analysis, people perform local resilience practices based on existing knowledge and memory. At this level, social learning often emerges from people's direct encounters with risks and catastrophic events. The third level of analysis involves formal and informal social institutions, which profoundly affect performance regarding DRR and community resilience (see section on institutions below). The fourth level of analysis concerns worldviews, belief, and values, which shape people's attitudes and responses to NTEE. Risk reduction and resilience to NTEE are a function of worldviews, belief, and values (Fig. 1), and these may be altered by exposure to NTEE and disaster risks (Oliver-Smith 2002).

Two aspects of this framework are noteworthy here: ILK as a "knowledge–practice–belief complex" is not static but rather a dynamic process that involves trial and error and the integration of new ideas and knowledge; and the four interrelated levels are not hierarchical, but rather are linked under a single nested framework with strong reciprocal relationships. Although all levels of analysis are important, for the purposes of this study, we focus on the ILK and the role of social institutions in reducing risk and building and/or strengthening community resilience.

Social Memory and Community Resilience to Nature-Triggered Extreme Events

Social memory is an "arena in which captured experience with change and successful adaptations, embedded in a deeper level of values, is actualized through community debate and decision making processes into appropriate strategies for dealing with ongoing change" (Folke et al. 2005: 453, also see Hewer and Kut 2010, Beilin and Wilkinson 2015). However, SM has diverse meanings and connotations (Olick 2016). We consider SM specifically in relation to NTEE and disaster shocks and its role in DRR and community resilience building.

Social memory is essential to a community's capacity to respond to shocks and it is a source of renewal and self-organization (Berkes 2007); it is argued that communities with higher SM tend to be more resilient (Folke et al. 2005). Human responses and resilience strategies in the face of disaster are shaped by the presence or absence of SM, as it is required for translating knowledge into action (i.e., the link between the first and second levels of our framework). However, SM has two major drawbacks: it tends to fade away with the passage of time, and it may provide a false sense of confidence.

Longer intervals between events tend to make SM less reliable. Intangible SM in the form of narratives and oral history is likely to fade away quickly if not renewed by recent disaster experience or vigorous institutional efforts. It is likely to be held by people who directly experienced past events, typically elders (Berkes and Folke 2002), and in the absence of a renewal mechanism, "only half of the population remembers the most intensive and extensive natural processes after ten years, and only a tenth after forty years" (Komac 2009: 206). Furthermore, because SM is based on past experience, it can provide overoptimistic and inaccurate expectations regarding the likely extremes of climate-change-induced events, and lead to surprises when future events exceed all prior experiences.

Institutions, Social Learning, and Resilience Building

The third level in Fig. 1 comprises social institutions—the formal and informal rules, regulations, and social norms governing a community (Ostrom 2008)—that can play a decisive role in nurturing, replenishing, and sharing SM both horizontally (actor to actor) and vertically (generation to generation). Socially embedded informal institutions play a critical role in generating and disseminating social learning and in the "memorialization" process (Tidball et al. 2010, Rumbach and Foley 2014). Formal institutions are increasingly taking responsibility for reducing disaster risks and building resilience to NTEE by creating collective learning platforms and promoting new scientific knowledge and ideas. In light of this trend, a vital question that has emerged is: do formal institutions take local voices, learning, ILK, and SM into consideration in the social learning process, or is the social learning process mostly top-down? Taking a critical stance on the role of formal institutions in social learning and resilience-building processes, we examine to what extent institutions shape the pathways of resilience (Wilson 2014).

Critical scholars argue that "resilience" is a contested concept with multiple meanings, interpretations, and political and ethical implications (Grove 2013*a*, 2018, Pugh 2013, Bonilla 2020). Addressing the question of "who" defines "resilience" and for "whom," MacKinnon and Derickson (2013) have noted that nonlocals (e.g., external donors and development agencies) often define community resilience, whereas the voices of the communities themselves are silenced. Understanding tensions and differentials in power and knowledge in such processes is central to comprehending and explaining the alternative meanings of resilience (Brown 2016, Pelling 2011, Boyd et al. 2014). In discussing the relationship between power and knowledge, Foucault ([1980], 2005) explains that through exercises of institutional power and the exclusionary processes involved, one form of knowledge becomes "truth" and others are rejected. Such processes may take place at local levels where locally relevant knowledge may be excluded by the power of prevailing institutions (Agrawal 2005).

However, for Foucault, power is not always oppressive and constraining but can also be productive, giving rise to new forms of interest, desire, capacity, and behavior. Such a conceptualization of power views individuals as active agents rather than passive subjects (Foucault [1978], 2005). The Foucauldian notion asserts that "the truth of resilience is not 'out there', objectively waiting to be discovered," but rather that the conceptualization and definitions of resilience are constructed through power relations. Thus, "critical research on resilience has shown that resilience initiatives create subjects with particular kinds of desires and capacities" (Anonymous reviewer, 3 July 2020, *personal communication*). Foucault argues that "where there is power there is resistance;" people are not merely victims of hegemonic norms, but rather strategically cope with the discursively produced and reproduced social domination (Cleaver 2007, Grove 2013*a*). Therefore, resistance is not always an overtly manifested act, but rather an expression of hidden, unconventional, and strategic positions (Brown 2016). Foucault's biopolitical analysis of power is also relevant in explaining the shift of the regimes of power, knowledge, and technologies beyond the state apparatus (e.g., toward NGOs) (see Grove 2014*b*). Biopolitics signals a "problem space" (i.e., hazards and disaster risks are governmental concerns) and a topological analysis of power "that examines how existing techniques and technologies of power are redeployed and recombined in diverse assemblies of biopolitical government" (Collier 2009: 79).

In recent years, a redeployment of power and authority has taken place both globally and locally, wherein state roles and responsibilities for disaster management have been delegated to local authorities according to what is commonly termed the "subsidiarity principle" (Melo Zurita et. al. 2015, 2018). Such delegation has frequently been performed by the state through partnering with NGOs and other civil society organizations (Choudhury et al. 2019). This approach assumes that local institutions, by virtue of being embedded in the community and building social capital and trust, are better equipped to deal with local shocks and stresses (Melo Zurita et al. 2018). Notably, these subsidiarity principle-based approaches often sidestep fundamental questions regarding how people are governed through decentralization processes and what effects such processes have upon peoples' vulnerabilities. From a biopolitical perspective, community-based disaster resilience programming is alleged to become the technology of biopower. The intimate operation of power to promote so-called experts' notions of resilience, which Agrawal (2005) describes as "intimate institutions," is also illustrated by this perspective.

Thus, a biopolitical reading of resilience is concerned with the techniques that produce knowledge to naturalize risks and uncertainties and to intervene in the lives of communities to help them cope and adapt to such changes (Chandler 2018, 2019). Evans and Reid (2013) explain that, in such analyses, resilience operates through the ontology of vulnerability, which Chandler (2019) termed "ontopolitics." Therefore, following biopolitical rationalities, the intent of resilience technologies is to make subjects resilient so that they have the capacity to adapt and to exploit situations of uncertainty in the face of a multiplicity of threats (Evans and Reid 2013, Hill and Larner 2017). The biopolitical interpretation considers agents as active and having control over their own lives, and criticizes traditional interpretations of resilience for considering (resilient) subjects as powerless and lacking agency and for ascribing any vulnerabilities to disasters to deficiencies in the subjects' abilities rather than flaws in existing disaster management systems (Bockstael 2017).

In the social learning process, ILK should therefore be considered in its own right for encouraging the local and indigenous peoples to pursue their own notion of resilience. As Barrios (2016: 35) argues, "[d]efinitions of resilience, recovery, and "rebuilding better," must not only be polyvocal, but must also foreground the voices of people and communities who directly bear the brunt of disasters," otherwise resilience-building processes may instead enhance vulnerability. In addition, in building resilience, the goal should be to provide resources to people and enable them to make their own choices, rather than implementing interventionist strategies (Kevin and Jonathan 2015, Evans and Reid 2014).

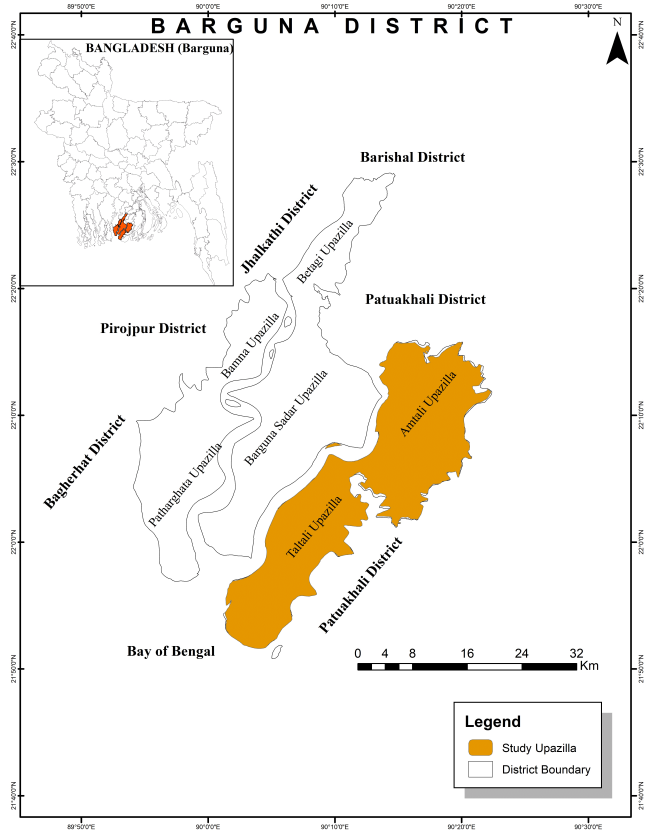
STUDY AREA AND METHODOLOGY

We conducted our study in the southern coastal zone of Bangladesh (Barguna district), which is ranked by Intergovernmental Panel on Climate Change (IPCC) models as among the most vulnerable areas (IPCC 2014). Over the last half century, recurrent severe tropical cyclones, originating in the Bay of Bengal, have made landfall into this region. Following the devastating human toll (approximately half a million fatalities) of Cyclone Bhola (11 November 1970), a 3–5 m elevated earthen dike system was developed to protect the coastal region, particularly from cyclone-associated storm surges. In recent years, Barguna district was most severely affected by Cyclone Sidr in 2007, which claimed 1292 lives, injured 16,310 people, and destroyed a great deal of property and infrastructure (Government of Bangladesh (GoB) 2008). Cyclones Aila (2009), Mahasen (2013), and Komen (2015) have subsequently devastated the district. We carried out our field investigation from August 2018 to January 2019 in two *Upazilas* (subdistricts) of Barguna district, namely Amtali and Taltali, covering six villages—two from Amatali (Baliatali and Gupkhali) and four from Taltali (Nidrarchar, Idupara, Tatulbaria, and Nolbonia) (Fig. 2).

We adopted a transformative interpretive framework (TIF) (Mertens 2007, Creswell 2013) in studying social learning processes for building community resilience to coastal cyclones and associated risks. The TIF framework acknowledges that

knowledge and its production within a society are value laden—that is, they reflect power asymmetry and shape social relationships. Therefore, the intent of knowledge production must be to change the lives of people and the institutions they live in (Mertens 2010, Creswell 2014). Community voices and participation are critical to the production of knowledge that is likely to facilitate transformative change and coping with oppression and subjugation (Mertens 2012, Thiessen and Byrne 2017). Parallel to resilience thinking, this paradigm focuses on the "strengths" within marginalized and disadvantaged communities rather than their "deficiencies" (Mertens 2009, Brown and Westaway 2011).

Fig. 2. Location map of the study area.



Our empirical investigation followed a community-based participatory approach. This is a transformative change approach to research that aims to unshackle people from oppressive-hegemonic power structures (Jacobson and Rugeley 2007), and in turn, facilitate change in the lives of participants as well as "the institutions in which they live and work" (Creswell 2007: 21). Our primary data collection involved techniques drawn from the participatory rural appraisal (PRA) toolbox, with a four-tier study design (Choudhury and Haque 2016). Before commencing fieldwork, the first author recruited a local field assistant who worked as a gatekeeper and translator of local dialects. Prior to collecting the data, several informal visits to the communities with the field assistant helped build rapport with community members. Appropriate verbal or written consent was obtained from each participant, following our protocol as approved by the University of Manitoba's (Canada) Joint-Faculty Research Ethics Board.

Considering the scope and objectives, the selection of respondents in the empirical investigation was made purposefully. We first conducted 50 semistructured interviews with community members who had firsthand experience with Cyclone Sidr. This talk-based method helped capture community members' diverse narratives on memory, experience, and learning from past major NTEE and associated disasters. We interviewed adult and elderly male and female members (30 males and 20 females). Interviews ranged from 30 to 90 minutes. The interviews included exploring: experiences of past major disasters; coping and adaptation strategies; what was learned from disaster experience; actions and roles performed by local formal institutions; application of learning to later events; and how early warnings (EWs) were formulated based on ILK prior to the disaster event.

In the second stage, we conducted 11 focus group discussion (FGD) sessions involving diverse occupational groups from six villages. Focus group discussions enabled capturing people's narratives on learning and experience with NTEE and disasters. We conducted six FGDs with males (two with farmers, three with fishermen, and one with a mixed group) and five with females. These diverse FGDs were organized in order to capture diverse dimensions of ILK, more recurrent features, and outliers. Community members interact with surrounding environments differently for livelihood due to their varied occupation and gender positions. Therefore, differential experiences and exposures to risks allow people to generate ILK on multiple and varied dimensions. For example, fishers are more capable of observing and documenting the maritime and riverine dimensions of ILK than farmers, who concentrate more on terrestrial dimensions.

In the third stage, we collected six oral histories (four males and two females) from elders (aged more than 65 years) who had experience of catastrophic cyclones before Cyclone Sidr (2007). This method made space for a "voice" or a "picture" of the past from the words and memories of the respondents. The main purpose of this investigation was to unpack the function of memory and elders' knowledge in building and maintaining resilience. The duration of these conversations ranged from 75 to 105 minutes.

In the final stage, we conducted five key informant interviews (KIIs) with representatives from community-based local institutions (e.g., local press club) to understand their roles in the memorializing and social learning process. The local press clubs in Amtali and Barguna shared images and news reports that highlighted their roles in this process.

Because formal institutions from outside the community profoundly shape the social learning and resilience building process, we conducted six KIIs with NGO personnel to understand how they carry out DRR and resilience projects at the local level. We also collected project documents to examine how external institutions view resilience and DRR. The first author participated as a "participant observer" in three social learning sessions organized by local NGOs to disseminate knowledge on DRR and resilience. Sample questions included in the observation protocol were: who participates in the platform

Table 1. Dimensions of LK and EW to reduce the risk of coastal cyclones and storm surges

Dimensions of LK	LK as EW signs and signals
i) Ecological (nonhuman behavior)	a. Ants stay together and climb to higher places b. Leafs of *Mantha* tree get curled c. Cows start starvation d. Seabirds and ducks start moving toward the shore** e. Churi (*Eupleurogrammus muticus*) and Loittia fish (*Harpadon nehereus*) start moving and jumping quickly in the sea*** f. Mosquitoes stick into the body of cows and goats g. Flying insects are less visible at night. They seem to be in a rush. h. *Guyalla* birds fly out to sea i. Livestock such as ducks and hens become reluctant to enter their shelters j. Small black birds start flying over the sea
ii) Phenomenological (feeling and anticipation of a probable disaster from past memory)	a. Elders sense an impending disaster based on past experience and memory ** b. Unbearably hot and humid weather for several days
iii) Sea/riverine (behavior and observation of river and sea)	a. Change in the color of seawater ** b. Warm seawater ** c. Water whirls and more vapors in the sea surface air d. Unusual patterns of water movement and flow in the sea e. Sea becomes darker f. Elevated water levels in the adjacent rivers
iv) Meteorological (related to wind movement, cloud, and temperature)	a. Wind from the southeast or east (locally known as *Eshan Kun* or *pubal* wind) brings water surges *** b. Hot and humid weather brings bad weather c. Wind from the west brings rain** d. Wind from the southwest is followed by recession of surge water *** e. When *juba* (high spring tide) combines with an easterly wind
v) celestial (condition of sky and moon)	a. Lunar day and month and associated high and low tides *** b. Lightning in the north/ northeast means strong wind and floods (this gives 10–12 h of warning) ** c. Lightning in the southwest means only rain d. If there is no thunder and lightning and if weather becomes silent (*gombir*), then there is the possibility of storm e. Lightning during the onset of storm reduces its intensity
vi) Official (i.e., information received by external institutions, electronic and print media)	a. Warning signals from radio, TV, and mobile phones ** b. Calls from family members and relatives c. Warning signals received from CPP (Cyclone Preparedness Program) volunteers

*** Most widely reported by community people
** Moderately reported
Source: Field data, 2018

(i.e., gender and age); do NGO-facilitated platforms take ILK and memory into account; do they disseminate and incorporate only scientific–technical knowledge in local programming or are other forms of knowledge included?

FINDINGS AND ANALYSIS

Dimensions of Indigenous and Local Knowledge, Early Warning, Disaster Risk Reduction, and Resilience

From the point of view of social learning, DRR, and resilience, we focused on two aspects of ILK: triangulation of ILK, and the possession and use of ILK within the community. Regarding the first aspect, we categorized local early warnings (EWs) for DRR and resilience under the six dimensions of ILK (Table 1). Often the role of ILK in DRR and disaster resilience is overromanticized, and its validity is not examined. We tried to triangulate some of the ILK-informed EWs against two other knowledge types: in relation to the onset of a particular cyclone disaster event (i.e., Sidr), and against established scientific explanations of pertinent phenomena. The most common and widely reported local cyclone EW feature is the direction and rotation of blowing wind. Wind from the southeast or east (*pubal batas*) pushes water surges toward the locality (Table 1, iv (a)), whereas wind from the southwest or west causes surges to recede (Table 1, iv (d)). Community members repeatedly reported that prior to the landfall of Cyclone Sidr, an easterly wind (*pubal batas*) was blowing for about 24 h, and continued until the water surge receded: "During Sidr, *pubal batas* was blowing, as soon as wind started moving to west then water started to retreat. We start to worry when *pubal batas* blows because it increases water [as storm surge]." People also reported that a few days before the landfall of Cyclone Sidr, the weather remained hot and humid (Table 1, ii (b)). Often people draw inferences combining multiple dimensions. For example, fishermen observed a change in the behavior of Churi (*Eupleurogrammus muticus*) and Loittia (*Harpadon nehereus*) fish, accompanied by a change in color and temperature of the ocean surface (Table 1), whereupon they attempted to return to shore ahead of the impending storm.

People in coastal Bangladesh often triangulate their own observations with cyclone EWs from official sources (e.g., Bangladesh Meteorological Department) and take measures to reduce risk from the potential cyclone's impact. One elder explained that Signal Numbers One, Two, and Three from official sources are "normal" but Signals above Number Seven are considered "dangerous" locally. Explaining the use of multiple sources of EW, one FGD member stated:

Table 2. Possession of various dimensions of LK by different groups of people

		Ecological	Phenomenological	Sea/Riverine	Meteorological	Celestial	Official
Occupational group	Fishers	***	**	***	***	***	***
	Farmers	*	*	*	***	**	*
	Others	*	--	--	*	**	**
Gender	Male	***	***	***	***	***	***
	Female	--	**	--	***	**	*
Age group (in years)	Below 50	**	--	***	***	**	***
	Above 50	**	***	**	***	***	*

*** most widely reported
** moderately reported
* less frequently reported

> *If the sky gets cloudy and pubal batas* [easterly wind] *blows, we assume that the weather will become bad soon. Then we check radio announcements* [broadcasts] *and use SMS services in mobile for weather information. If we hear Signal Number One, we start sailing toward the shore thinking that it may become worse soon.*

Established scientific evidence matches some of the EW features and signs most widely reported and applied by the local people. Our primary intention here is not to validate ILK with scientific knowledge or to nullify; rather, it is to triangulate ILK from various pertinent sources.

The first sign used by fishers to predict impending cyclones is a significant increase in sea surface temperature (SST). In the scientific literature, the relationship between cyclogenesis and SST is well established, with cyclonic activity generally occurring when the SST exceeds 26°C (Henderson-Sellers et al. 1998, Trenberth 2005). As the SST increases, the intensity of cyclonic storms is likely to increase as such storms are fueled by water vapor (Khan et al., 2000, Kossin 2017). During the tropical storm Nargis (2008), which eventually made its landfall in Myanmar causing the death of more than 130,000 people, the SST of the Bay of Bengal was recorded to be over 30°C (Maneesha et al. 2012).

Scientific evidence also supports fishers' observation that the color of the sea changes prior to cyclones, as increasing water temperature triggers an increase in phytoplankton, whose pigment in turn absorbs sunlight and further raises the SST (Hernandez et al. 2017, Zhao and Wang 2018). It must be noted that this relationship may not always be linear due to other intervening variables at different temporal and spatial scales (Dunstan et al. 2018).

The second major sign used by local communities to gauge the onset and intensity of cyclonic storms is wind direction. Specifically, an easterly wind (*pubal batash*) brings storm surges and tidal flooding—a relationship confirmed by meteorological research (Wicks and Atkinson 2017). A third major sign observed by fishers is the behavior of coastal fish species (e.g., *Eupleurogrammus muticus* and *Harpadon nehereus*) in response to rising SST. Secor et al. (2019) and Spampinato et al. (2014) observed such a change in the behavior of fish species during tropical cyclones, although they did not specifically link this behavioral change to SST.

The possession and use of different dimensions of ILK within the community is helpful in understanding the interaction between social learning, DRR, and community resilience. We examined how the structural location of individuals shapes the possession of different dimensions of ILK by documenting the structural locations of community members according to occupation, gender, and age. These groups of people were not mutually exclusive and often overlapped (Table 2). For example, fishers and farmers are all male and belong to both adult and elderly age groups. Our findings indicate that specific groups hold certain dimensions of ILK more than others (Table 2). For example, ecological dimensions were most widely reported by fishers (who are mostly male), whereas the major determinant for reporting the phenomenological dimension (i.e., SM) was age and experience (both male and female). Persons above 50 years old have experienced past disasters firsthand and acquired knowledge through observation and intergenerational knowledge transfer. Fishers' direct interactions with the sea and rivers made them the major holders of the sea/riverine ILK dimension. Meteorological and celestial dimensions are not influenced significantly by structural locations. Fishers, males, and adults (below 50 years) tend to look for EWs from official sources more than females. Such variation of ILK within the community in terms of structural locations and other determinants validates the importance of social learning processes for community resilience being system-wide (i.e., community) learning (Berkes 2007, Pahl-Wostl 2009).

Interplay between Indigenous and Local Knowledge and Social Memory in Shaping Resilience

A key question that arises from the preceding section is: why do community people suffer from loss and damage despite possessing rich ILK? We posit that responses and resilience strategies in the face of NTEE and disasters are largely shaped by the state of SM, which is a necessary condition for translating knowledge into action (Fig. 1). Here, we elaborate our points through an examination of the interplay between SM and ILK in two temporal phases: pre-Cyclone Sidr memory and its impact during the cyclone itself, and the current state of Cyclone Sidr memory and its role in later events.

PreSidr memory, indigenous and local knowledge, and resilience

We have documented four interrelated factors that made Cyclone Sidr a surprise for most of the communities, despite their receiving

EWs from multiple sources, including government agencies (e.g., volunteers from the Cyclone Preparedness Program (CPP), relatives, and neighbors). The first factor is the absence of SM of cyclonic disasters. The last major cyclone disaster before Sidr in 2007 was Cyclone Bhola in 1970. The 37-year gap left most community members with no fresh memories of the previous disaster, leading many to not take EWs obtained from ILK or government agencies seriously. Focus group discussion members explained why they were not able to apply their knowledge during Sidr:

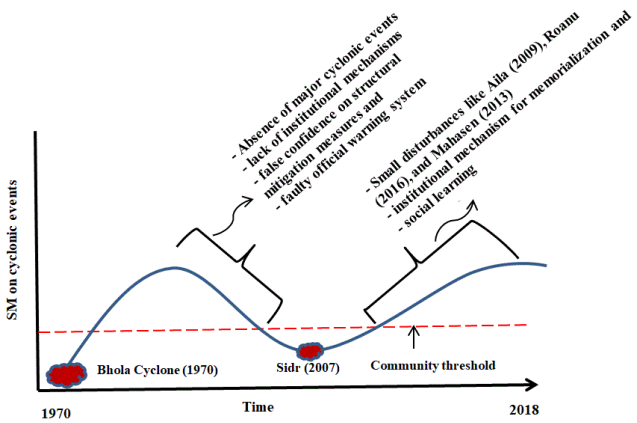
> *No one here* [present for FGD] *witnessed any event like that before. Probably only one had such an experience. Then how could we know that? ... Sidr started in the late afternoon; we did not realize that can actually happen. Elders used to say about floods, but we did not experience anything like that before...*

The second factor is the nonlinearity of cyclonic events. Before Sidr, some people had memories of storms (locally called *dabar*) and their associated ocean-water surges, but few had experienced severe cyclones and the associated storm-surge-induced flooding (cf. Brammer 1990). Monsoon flooding normally occurs slowly enough to allow time to prepare for its arrival, but the onset of a cyclone-induced storm surge is much faster than rainwater or riparian flooding. People in the studied communities had experienced floods in 1972 and in 1988, but nothing similar to the scale of Cyclone Sidr. As one participant stated:

> *In case of past floods, it took 2 to 3 days for flood water to rise to 6 to 7 feet, or a maximum 10 feet. During Sidr, water came and receded within a half an hour; it washed away everything within just blink of eyes ... we did not experience anything like Sidr before ... we could not imagine the magnitude of the event.*

Positive SM is likely to trigger responses necessary for reducing risks and building resilience, whereas negative SM can have the opposite effect, making people reluctant to take action. One source of negative SM is people's false confidence in structural flood-prevention measures, such as embankments (Fig. 3). As no community members had previously seen floodwater encroachment inside the dikes, they assumed such dikes would be able to withstand Cyclone Sidr's surge waters.

Fig. 3. Temporal dimension of SM and resilience implications.



Another source of negative SM is feelings of mistrust toward official EW announcements (Fig. 3). Before Sidr, people often received false disaster warnings, typically from government agencies. For instance, there was a cautionary tsunami warning along the coastal areas in September 2007 (2 months before Sidr) due to the Sumatra earthquakes and Indian Ocean tsunami, forcing many communities to evacuate. No tsunami arrived, and subsequent warnings about Cyclone Sidr were widely ignored. A respondent noted:

> *We used to ignore early warnings because nothing happened after reception of cyclone warnings; therefore, we did not trust early warning announcements. We did not believe that Sidr would actually happen.*

In addition to the absence of positive SM and the presence of negative SM, Sidr came as a surprise to many communities because the celestial dimension of ILK was unable to predict the danger of a storm surge. Locals in these areas use lunar phases to predict the tides, with the term *Juba* used to denote high water levels (high spring tides) and *Dala* to denote low water levels (low spring tides) (see Fig. S.1 in Supplementary Material). As Cyclone Sidr struck during *Dala* and low tide, locals did not anticipate a storm surge over 15 feet in height was possible.

In contrast, the presence of positive SM in combination with ILK can make a significant difference in terms of DRR and resilience. We found that, in coastal Bangladesh, community elders, for whom Cyclone Sidr was not a novel event, held primarily positive SM. An elder lamented that, "I told everyone that if *pubal batash* [easterly wind] does not weaken within 24 h, there will be a storm surge and flood. No one believed me." In some cases, however, the memories of the elders, combined with EWs from ILK and government agencies facilitated the undertaking of DRR actions before the onset of the cyclone.

Drawing on their SM and ILK, elderly members could foresee impending risks and potential disaster and help younger community members avoid property damage and loss of life. One young adult respondent (age 35) stated that, "[m]y father warned us about a probable storm surge and flood; he asked us to take shelter and store some rice in a safer place."

Memory and learning from Sidr for later events

After Cyclone Sidr in 2007, EWs were issued prior to Cyclones Aila (2009), Mahasen (2013), Komen (2015), Roanu (2016), and Mora (2017). During those events, locals took official government EWs more seriously and more willingly undertook measures, such as evacuation, to reduce risks. Some of the survivors of Cyclone Sidr recounted how narrowly they escaped injury or death, the actions they took to cope with the immediate impact of the cyclone as it made landfall (e.g., climbing big trees, grabbing big plastic containers, and rushing to the embankment for safety), and their ignorance of the potential severity of the storm prior to its arrival.

Many community members have since embraced the lessons learned from Cyclone Sidr (Table 3). For example, a large proportion now immediately rushes to cyclone shelters upon receipt of government EW. However, since there have been no cyclones on the scale of Sidr since 2007, memory of catastrophic disaster experience has been gradually eroding, and people are becoming more reluctant to evacuate to shelters. As one key

Table 3. Learning, coping and adaptation practices in study communities

Dimensions	Specific learning
Coping	Taking shelter either on the embankment or in cyclone shelters or preparing to evacuate entirely; Returning from the sea upon receiving EW; Taking measures to save property and valuable goods before evacuating; Preparing to take shelter in a neighbor's house with a stronger structure; Keeping locally available materials (e.g., bamboo trees and big plastic containers) ready to cope with coastal flooding;
Adaptation	Raising house platforms; Moving houses away from the riverbank or seashore and close to or inside the embankment; Learning that children, (especially pregnant) women, the elderly, and people with disabilities are more vulnerable and require priority aid; Building houses with a stronger structure;

informant observed that the number of people who immediately flee to shelters was much higher in the years immediately following Sidr compared with the time of the study (2018):

> *We received early warning during Sidr, but we could not realize the severity as we did not experience anything like that in recent past. We take shelter now if we receive the early warning. During Mahasen and Aila, most people left their houses for safety. After Sidr, people began to take warnings more seriously, which they did not do before. People did not understand and used to ignore early warnings before...*

Community-Based Institutions, Memorialization, and Social Learning

This section focuses on the role of socially embedded practices and other local institutions (e.g., local media) in facilitating social learning and the memorialization process (the third level in Fig. 1). One important mechanism for social learning embedded in rural Bangladeshi culture is the *adda* (hanging around), an informal platform for sharing personal experiences. The location of *adda* varies for men and women, with men typically gathering in village marketplaces to socialize over a cup of tea and women gathering in a courtyard. Information gathered is then shared with the rest of the participants' families.

In these informal sharing platforms, community members shared their memories of survival during Cyclone Sidr and drew lessons from each other's experiences. One key lesson was how to recognize existing risks and take them more seriously. Stories related to survival and death matched with elders' advice and knowledge (e.g., not to panic and rush or try to evacuate during the onset of the storm surge). During our field research, Cyclone Titli (2018) was forming in the Bay of Bengal. The resulting atmospheric depression generated continuous rainfall, during which many community members gathered in local tea-shops to hold *adda* and discuss their previous experiences with severe weather. *Adda* thus functions as an important and effective mechanism for replenishing SM.

Local institutions, such as the Bangladesh Red Crescent Society (local unit), local press clubs, and other community-based organizations play a critical role in social learning and the memorialization process. For example, the local press club in the study area organizes a memorial event to remember Cyclone Sidr on every 15 November; they organize rallies, show videos of Sidr, and hold group discussions. A memorial to the disaster was also built in a local cemetery, and local newspapers publish feature articles on Cyclone Sidr every year (Fig. 4).

Fig. 4. Observing Sidr Day on 15 November by the Bangladesh Red Crescent Society, Barguna Unit (4.a), and Barguna Press Club (4.b). Photo courtesy of: Barguna Press Club.

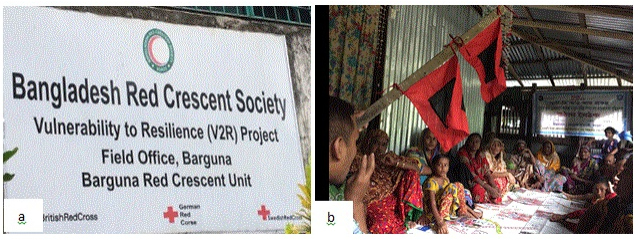
Formal Institutions, Denial of Indigenous and Local Knowledge, and Processes of Making Resilient Subjects

In Bangladesh, there has been a major institutional shift regarding disaster management in recent decades, with many disaster management initiatives being decentralized and handed over to local institutions, especially through partnering with NGOs (Choudhury et al. 2019, Haque and Uddin 2013). This process is driven by an increased focus on local resilience in the national policy discourse, which is reflected in the National Plan for Disaster Management (2016–2020): *Building Resilience for Sustainable Human Development* (Ministry of Disaster Management and Relief (MoDMR) 2017). In addition, international donor agencies have implemented numerous large projects for building resilience, such as the National Resilience Program (US$2.25 M) run by the United Nations Development Program. Local-level disaster management institutions, such as NGOs, have been implementing community-based disaster resilience projects, where the notion of resilience has been predefined by policy makers and external donor agencies (Fig. 5*a, b*).

Local-level NGOs implementing disaster resilience projects consider NTEE and associated disasters to be a technical, financial, and biological problem. With a predetermined framework, their fundamental intention in reducing risks and building disaster resilience is to train people in strategies and techniques that can help save "biological lives." Interventions by NGOs here reflect the government's biopolitical agenda: the

national government frequently presents itself as a success story, stating that it succeeded in significantly reducing NTEE-related fatalities through institutional interventions (Paul 2009). As Marchezini (2015) argues, state agencies often create a false sense of optimism via these claims, and distract attention from the actual needs of locals.

Fig. 5. Billboard of the project on disaster resilience (5.a); a community training session flag numbers and EW signals (5.b).



In the study area, in line with biopolitical rationalities, local NGOs have created social learning platforms where ILK, memory, beliefs, and practices are largely ignored. As well, people are treated as objects of scientific and expert knowledge and subjected to externally defined notions of resilience, as subjects assumed to be vulnerable and deficient in their ability to cope with shocks associated with coastal cyclones. Resilience to coastal cyclones therefore implies local people understanding and internalizing the meaning of the official EW signs and signals and responding to them in a preordained manner, e.g., by evacuating to a cyclone shelter. Nongovernmental organizations inform people through official EW systems (Fig. 5*b*), which were originally established during the British colonial period for seaports (Roy 2012). The Bangladesh Meteorological Department continues to generate EWs and associated signals for sea and river ports, which are provided to volunteers of the Cyclone Preparedness Program to be disseminated to local communities via the Department of Disaster Management. Nongovernmental organizations also train people on preparedness, risk reduction, and postdisaster recovery strategies (Fig. 5 *a, b*).

We observed three interrelated factors that facilitate this top-down learning mechanism and subject-making process. First, the absence of preSidr cyclone memories and traumatic memories of the Cyclone Sidr disaster have created an opportunity (i.e., "problem space") for formal institutions to intervene in people's lives. Before Sidr, there were no or merely nominal intervention programs or projects on DRR and resilience. The preceding discussion highlights that young and adult people had no cyclone disaster memory prior to Sidr, which contributed to their traumatic experience of Sidr. Education programs by NGOs on DRR and resilience appeared to be attractive for these local community members in the absence of positive SM.

In the study area, all of the six surveyed NGOs have adopted a community-based and participatory method to implement projects for DRR and enhancing resilience, as defined by the formal institutions, to cyclones and storm surges so that people can cope and adapt to surprises, shocks, and catastrophes. Initially, NGOs (e.g., Nazrul Smriti Sangsad (NSS), Community Development Centre (CODEC), and JAGO NARI) formulated community-based organizations (CBOs) comprised primarily of young and adult men and women. Through these CBOs, monthly courtyard meetings with women were organized where they discussed disaster preparedness along with other social issues, such as health, hygiene, domestic violence, and child marriage. With male CBO members, NGOs provided training, with supporting technical manuals, on evacuation, rescue, and first aid, and conducted scenario exercises such as mock drilling. A respondent stated that:

> *"They* [the NGOs] *came after Sidr and taught us how to tackle disasters. ... They told us that we have to keep our eyes open for any surprising extreme events that may stem from natural or other forces. ... If early warning signal moves up to number 10, as we become aware* [prepare], *we can reduce loss and damage. ... We learned from Climate-Resilient Ecosystems and Livelihoods (CREL) Project."*

Second, people feel motivated to participate in NGO projects and social learning platforms as they expect some material gain from their participation. As most NGOs work with so-called "hard-core" poor, disaster resilience projects are often paired with health and livelihood-building initiatives (e.g., providing sewing machines, cash, or materials to install a tube well or toilet). We observed evidence of some people's strategic participation in NGO-led learning platforms primarily for material gain as way to address poverty-related suffering and supplement income, which can be regarded as the "hidden script" of such participation. Community members who did not receive any material incentives from NGOs tended to withdraw from the learning platforms. One woman explained: "[t]hey gave [sewing machine] to others. I went to their office for training for 3 years but did not get one ... this is why I do not take part any more." A male responded similarly: "I took training with Caritas [an NGO] for 3 years, but I did not get any benefit from them. When they donated goats and other things, they did not give them to me. ... At the end I withdrew myself."

Third, we observed that the predesigned frameworks of most NGOs did not allow elders a space in the social learning process, leading to their knowledge and memory being systematically excluded. An elderly respondent stated: "I am old, why would they call me? ... They want young, who can walk or travel to go for training in Amtali and Patuakhali, and Barisal [at distant locations]. They recruit mostly young people, and do not consider the elderly at all." Because the institutions hold power and draw authority from technical-expert knowledge, exclusion of ILK from their social learning processes is common, whereas, in the local context, ILK is the more valid form of knowledge. Through these types of practices, local organizations were seen to function with a preset structure to include and exclude various community people.

Explicit exclusion of ILK has been registered not only from the social learning processes, but also in local DRR and management decision making. As part of decentralization and localization of disaster management, the local governmental institutions at the Union Parishad (UP) level—the lowest level of the administrative hierarchy—are responsible for planning, including evacuation and response plans and DRR program implementation. In the

study area, the UPs formed disaster management committees, called Union-Parishad Disaster Management Committees (UMDC) to carry out these activities. None of the UMDC members were elders, nor have they been consulted in the formal processes. The UMDCs consisted mostly of local elites and representatives from different professional groups who collaborated with NGOs to implement planning and training activities. An examination of training manuals and planning documents revealed the total absence of ILK and SM in them. A representative from an NGO explained:

> *While working with UP and UDMC, we mostly work with the guidelines provided by the national and district level administration and, when needed, consult with the local elites as representatives from the community. However, as community members trust us, in some exceptional cases, we consult with community members at the grass-root level.*

During fieldwork we observed that, through a community-based participatory approach, NGOs sometimes attempt to incorporate local needs and knowledge in the disaster planning and response process. For example, prior to preparing local risk and resources mapping, an NGO (NSS) organized FGD meetings with community people. In the deliberations, people identified the usual timing of NTEE, including saline water intrusion during the winter season (December–February) and cyclones and storm surges during the monsoon (April and November). Indigenous and local knowledge thus received some attention and was being incorporated into such planning. In addition, in the participatory learning platforms, NGO workers collected information and knowledge of local people's (traumatic) memory of cyclones and storm surges to lay the groundwork for disseminating scientific–technocratic knowledge on EW and textbook ideas of preparedness.

Our research findings reveal that community people can generate EWs from various dimensions of ILK to reduce risk of loss and damage and enhance resilience to coastal cyclones. However, in formal social learning processes, such forms of knowledge are generally subjugated to a scientific–technocratic form of knowledge on EW, preparedness, and evacuation. Therefore, community members were being taught only the meanings of official EW signs and signals. In the absence of prior positive SM and with prevailing traumatic SM of Sidr, scientific–technocratic forms of knowledge appeared attractive to young and middle-aged participants.

The key to translating knowledge into action for building resilience is the presence of positive SM, which is mostly held by elders. Moreover, elders successfully combined official warnings with ILK to generate their own EWs, and those who listened to them were able to avoid loss and damage. Because the social learning platforms systematically exclude elders, important dimensions of ILK, positive SM to translate this knowledge into action, and elders' capacity for integrating scientific–technocratic knowledge with ILK are frequently excluded as well. People therefore are likely to ignore EWs from official sources (as discussed earlier) and from ILK, and suffer losses and damages as a result. Thus, the imposition of scientific–technocratic knowledge and subjugation of ILK by community-based resilience programming may in many cases enhance vulnerability rather than resilience.

DISCUSSION AND CONCLSUION

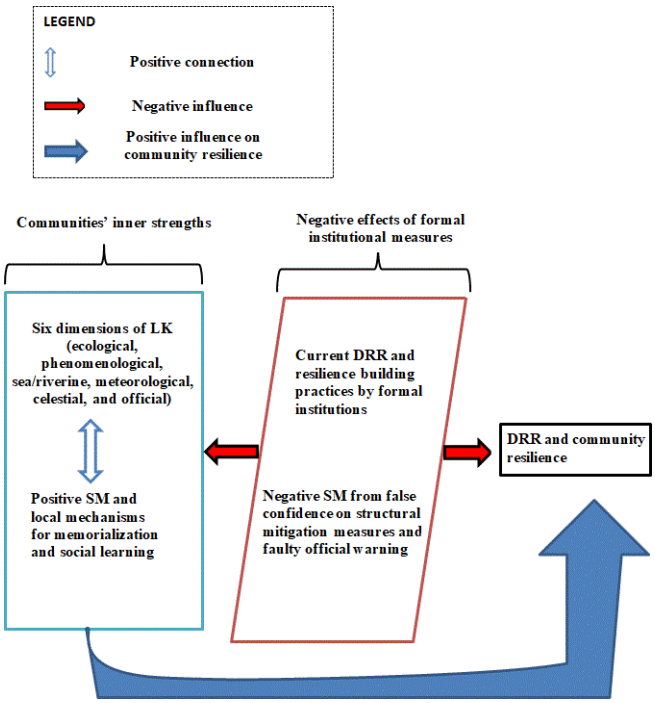
The fundamental linkage between social learning and community resilience to NTEE and associated disasters was our point of entry into this investigation. We took a critical stance on the programmatic intervention of community resilience and social learning and argued that local knowledge, beliefs, practices, and SM are crucial elements in the social learning process for building community resilience to NTEEs and disasters. Our findings are novel in three respects: (i) alternative possibilities for and local notions of resilience are undermined when ILK is unevenly folded into programmatic interventions for social learning and resilience building, which can paradoxically make communities more vulnerable to environmental extremes; (ii) by combining various dimensions of ILK with SM and official warnings and information, local knowledge holders can successfully generate accurate EWs to reduce risks due to cyclones; and (iii) the asymmetrical distribution of ILK in terms of occupation, gender, and age across communities highlights the value of social learning for system-wide (i.e., community) learning and building community resilience to NTEEs.

These findings have serious implications for the development and implementation of future strategies for reducing the increasing risks posed by climate-change-induced hydrometeorological extreme events like tropical cyclones (Woodruff et al. 2013, Marsooli et al. 2019, Uriarte et al. 2019). To cite some recent examples, Hurricane Harvey in the southern United States of America brought with it unprecedented volumes of rainwater for which most communities were not prepared, and the later Category 5 Hurricane Irma lasted far longer than any storm of its size in history (Rahmstorf 2017). We found that community people have rich stocks of ILK that help in generating EWs to reduce disaster risks and build resilience to coastal cyclones. However, climate-induced shocks could still appear as a surprise for community people. Cyclone Sidr struck as a surprise to many coastal communities as they were unable to predict the storm surge danger with the celestial ILK dimension. Some studies, however, suggest that some communities are capable of adapting well to climate extremes that surpass the parameters predicted by IPCC scenario-building models (Nyong et al. 2007), whereas other communities are struggling to adapt with their ILK (Lebel 2013, Kagunyu et al. 2016). In this regard, several authors rightly argue for collaborative knowledge production for building resilience and facilitating effective disaster management (Srivastava 2012, Sitas et al. 2016, Rodela and Swartling 2019). By integrating ILK with scientific knowledge to formulate and disseminate EWs, the risks posed by climate-induced disaster shocks can be substantially reduced (Fig. 6).

The problem of ILK and technical–scientific knowledge integration raises some critical questions: how can this potential integration take place, and what are the power–knowledge dynamics within an institutional context that in turn shape social learning processes and resilience outcomes? Most proposals and efforts have hitherto sought to integrate ILK with scientific knowledge via community-based participatory approaches (Tran and Rodela 2019). Nadasdy (1999, 2005), however, cautions regarding an integration process where ILK is unevenly folded into formal institutional practices, and as a consequence, efforts to build and/or enhance resilience through community-based interventions may have the unintended consequence of eroding rather than enhancing resilience. Our study demonstrates that

NGOs tend to consider ILK in community-based resilience programming in some cases merely to lay the groundwork for disseminating scientific–technocratic knowledge on EW and preparedness.

Fig. 6. Interconnections between communities' inner strengths and formal institutional measures, and their effects upon DRR and community resilience.



It can, therefore, be argued that the goal of social learning processes should be to nurture and build upon local strengths for developing communities' own conceptualization and components of resilience. In this regard, Berkes and Folke (1998) argue that a resilient system has inbuilt "social mechanisms" based on local knowledge that act as buffers against disturbances and maintain community resilience. Rather than solely relying on conventional interventionist strategies, the goal should be to recognize the power of human agency, dignity, and capability at the local level, and to provide and cogenerate the resources necessary so that communities can make their own choices for building and enhancing resilience (Kevin and Jonathan 2015, Evans and Reid 2014). Our study in coastal Bangladesh provides evidence that the local community have adopted modern technologies and knowledge in their own way to generate EWs to coastal cyclones. Hilhorst et al. (2015) have similarly found that indigenous people proactively adopt modern technologies to adapt with changing circumstances.

Although social learning is a process of collaborative knowledge production, and the knowledge produced through these processes shapes resilience pathways (Barrios 2016, Boyd et al. 2014), state agencies and formal institutions (e.g., NGOs) are increasingly taking unilateral, interventionist approaches to enhancing resilience to natural hazards (Grove 2013*a*). Our critical stance on the role of formal institutions in the social learning process highlights the empirical evidence that formal institutions do not recognize the significance of ILK, and therefore operate on the basis of predesigned resilience frameworks defined by nonlocals and external policy makers (Fig. 6). Indigenous and local knowledge is thus excluded from programmatic social learning processes, leading to the subjugation of local community members to externally defined conceptions of resilience and consequently reducing learning from such events to biopolitical rationalities (Hofmann 2014). Furthermore, because these social learning platforms systematically exclude elders and other local sources of ILK, key dimensions of ILK and the positive SM necessary for translating knowledge into action are excluded too. Due to this lack of cogenerated knowledge and reliable information, people are likely to ignore EWs from official sources and from ILK, and consequently suffer loss and damage. The imposition of scientific–technocratic knowledge and subjugation of ILK by neoliberal community-based resilience programming may enhance vulnerability rather than building communities' inner strengths and capabilities.

The relationship between ILK and SM is often not clearly delineated. Most studies on DRR and resilience either address ILK or SM separately or only mention one in relation to the other (cf. Garde-Hansen et al. 2017, Moreno et al. 2019, Setten and Lein 2019). Our detailed examination of ILK and SM emphasizes that SM is a necessary condition for translating knowledge into action (Fig. 6). We also observed that community members' responses to disaster risks are shaped by the nature of their SM, despite having a rich stock of ILK. Such gaps are also known as the "temporal variability in hazardscapes" (de Vries 2011). Madsen and Mullan (2013) argue that as NTEEs and disasters are episodic events, each event is remembered and considered as an isolated event rather than as part of a larger trend. In our study communities, people were familiar with gusty winds and monsoon rain but they had no prior SM of severe cyclones and associated storm-surge-induced flooding, and therefore, the impacts of Cyclone Sidr were a complete surprise for most communities. This resonates with Berkes and Ross's (2013) observation that the attributes of community resilience tend to differ depending on the types of shocks experienced (e.g., floods or wildfire). However, the presence of positive SM (mostly held by elders) made a significant difference in terms of risk reduction and resilience, which has also been documented in other contexts (e.g., Berkes 2007, Osterhoudt 2018) (Fig. 6).

In this article, we attempted to integrate scholarship on social learning, community resilience, and ILK, and address the issue of gaps between the community resilience literature and some of its social science critics (cf. Grove 2014*b*, 2014*a*, Hill and Larner 2017). Regarding the former, we found that using ILK as the point of convergence between the social learning and the community resilience literature helps to substantially improve our understanding of actual social learning and resilience building processes. Regarding the engagement of critical social theories with the current community resilience literature, we hold that the former present a similar argument, i.e., in building resilience, the focus should be on building upon a community's strengths rather than simply correcting its perceived weaknesses. Further efforts are required for bridging these literatures, including critical engagement and interaction, dialog and deliberation, and integration and knowledge cogeneration, as one anonymous

reviewer succinctly states that, at present the "two strands of literature ... often talk past each other," and this needs to be transformed into "meaningful interaction."

In this article, we limited our investigation to whether the established, formal institutions consider local voices, learning, ILK, and SM in social learning processes, and whether these processes are characterized mostly by a top-down structure. There is also a need to investigate the synergies among learning at different institutional levels and mechanisms for scaling-up learning from community and lower level institutions to higher level institutions. Although we specifically focused on the role of social learning in shaping community resilience and the role of locals as active agents in such learning processes, further research needs to be carried out on how other forms of learning (e.g., transformative learning) function to shape community resilience. Further research on how worldviews, beliefs, values, and other cultural factors shape learning and resilience building processes is also needed. Specifically, the views, meanings, and interpretations of community people concerning resilience to NTEEs and disasters and the roles they can play in the coproduction of pertinent knowledge need further attention. As an anonymous reviewer appropriately suggested, "it is important to consider potential tensions or clashes in attitudes and knowledge among [heterogeneous] indigenous people and inequities within local power structures" in the analysis of efforts to integrate ILK and scientific knowledge. We agree that such diversities and complexities should not be overlooked, but rather demand indepth examination.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/12107

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Data Availability:

The data/code that support the findings of this study are available on request from the corresponding author, [CEH]. The data/code are not publicly available due to institutional agreement-based restrictions, e.g., their containing information that could compromise the privacy of research participants.

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APPENDIX 1

In scientific literature, *Juba* and *Dala* are explained as spring tides (when the earth, the moon, and sun are in alignment). During a new moon, the gravitational forces of the moon and the sun pull along the same direction resulting in high water level (i.e. *Juba*). During a full moon, the gravitational forces of the sun and the moon exert forces in opposite direction resulting in low level of water (i.e. *Dala*) (Fig. S.1) (Gönnert and Sossidi, 2011; Park and Suh, 2012). When a high tide coincides with *Juba* it produces a very high level of tide (i.e. higher than average) and conversely, when low tide coincides with *Dala* it produces a very low level of tide (i.e. lower than average). During Cyclone Sidr, it was low tide with low spring tide (lower left Quatrain in Fig. S.1).

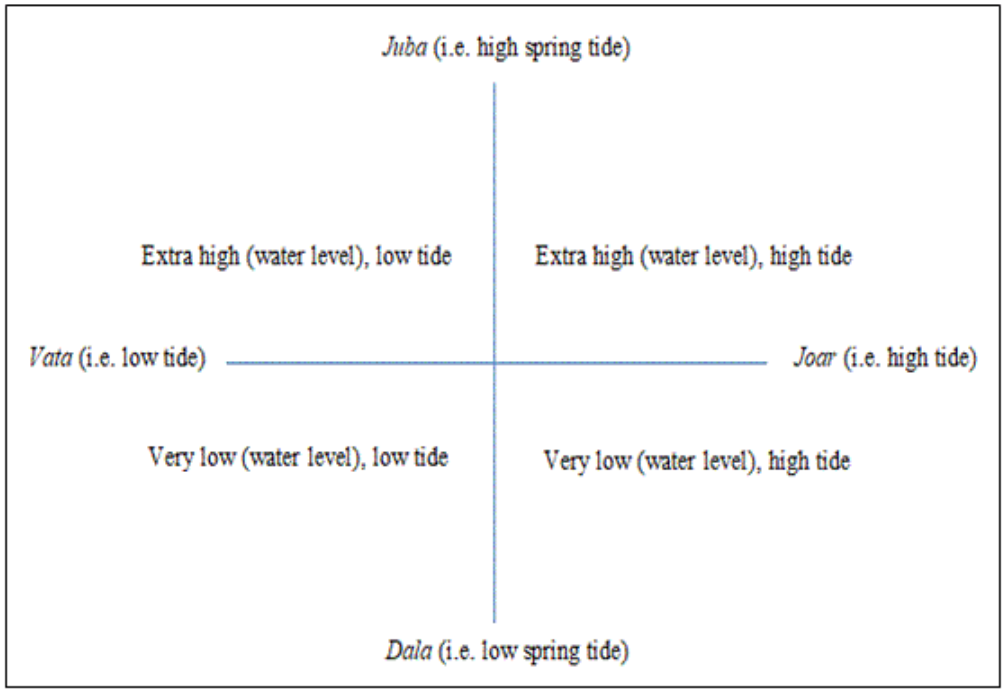

Fig. S.1: Connection between spring tides with high and low tides

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